

Studies on the Weak Charges of Particles

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Abstract

In order to include massive neutrino theoretically, a new concept of the weak charges of the particles, fundamental fermions, intermediate bosons and hadrons, is introduced. A new conservation law of the weak charge is first reported. According to the chirality of the weak charge the origin of parity nonconservation in the weak interactions is reasonably explained. According to the symmetry of the weak charge, an extension of the standard model is proposed. In this scenario, all the three generations of neutrinos are massive Dirac particles; both the right-handed neutrinos and the right-handed neutral baryons have zero weak charge, and so they do not take part in the weak interactions.

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In spite of its tremendous successes when confronted with experiment, the standard model (SM) has some shortcomings and leaves unanswered many fundamental questions. Perhaps one of the important outstanding problems amongst them is the neutrino mass, which would have a significant impact on astrophysics, cosmology and particle physics. In the SM neutrinos are exactly massless. However, theoretically here is no compelling reason for massless neutrinos, and there exists already a vast literature on the model of massive neutrinos [1]. Many extensions of the SM contain neutrinos with Majorana or Dirac masses. Experimentally there is now a host of evidence for neutrino oscillation [2], and that is most naturally explained if neutrinos are massive and mix with one another. Especially, the recent result of Super-Kamiokande collaboration [3] gave the mass squared difference $\Delta m^2 = 5 \times 10^{-4} - 6 \times 10^{-3} \text{ eV}^2$ and the mixing angle $\sin^2 2\theta > 0.82$. Therefore, some physicists believe that neutrinos might indeed have a very small mass [4]. If neutrinos have non-zero mass, it will radically alter our understanding of the violation of parity conservation law in the weak interactions and implies physics beyond the SM of particle physics [5]. The massless neutrinos are inevitable outcome of the parity nonconservation in the weak interactions. Therefore, in order to include massive neutrino theoretically, a possible suggestion is studying the root cause of the parity violation in the weak interactions. In fact, as early as 1982 Professor Yang emphasized again that a more fundamental origin of the violation of discrete symmetry should be investigated [6].

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In this paper we will be forced to propose the concept of the weak charges of the particles in order to study the above issues. The weak charges of the fundamental fermions are introduced by analogy between the interaction Lagrangian for neutral weak currents and the electromagnetic currents, the weak charges of the intermediate bosons by analogy between the Lagrangian terms describing the self-interaction of gauge fields. The weak charges of some baryons and mesons are calculated. The question of parity nonconservation in the weak interactions is explained by the chirality of the weak charge. The conservation law of the total weak charge is tested in all interactions and the conservation law of the chiral weak charge, in the weak interactions. In the last section the SM is extended to include the right-handed neutrinos.

I The weak charges of particles

I.1 The weak charges of the fundamental fermions

The existence of the three generations of the fundamental fermions, leptons and quarks, has been established in the SM. We shall confine ourselves to considering only one of them, e.g., first generation because they are absolutely alike. According to the SM we choose the group $SU(2) \times U(1)$ as the gauge group, and the left-handed (LH) fermions as the $SU(2)$ -doublets and the right-handed (RH) fermions as the $SU(2)$ -singlets,

$$\ell_L = \begin{pmatrix} \nu_L \\ e_L \end{pmatrix}, \quad q_L = \begin{pmatrix} u_L \\ d_L \end{pmatrix}, \quad e_R, u_R, d_R. \quad (1)$$

The Lagrangian of the model contains the terms describing the electromagnetic and the weak interactions. The Lagrangian for the electromagnetic interactions of the fermions is

$$\mathcal{L}_{em} = -\frac{g_1 g_2}{\sqrt{g_1^2 + g_2^2}} \bar{e} \gamma_\mu A_\mu e + \frac{2}{3} \frac{g_1 g_2}{\sqrt{g_1^2 + g_2^2}} \bar{u} \gamma_\mu A_\mu u - \frac{1}{3} \frac{g_1 g_2}{\sqrt{g_1^2 + g_2^2}} \bar{d} \gamma_\mu A_\mu d, \quad (2)$$

where A_μ denotes the electromagnetic field. We see that the rationalized electric charge is

$$e = \frac{g_1 g_2}{\sqrt{g_1^2 + g_2^2}}, \quad (3)$$

where g_1 and g_2 are the coupling constants corresponding to the groups $U(1)$ and $SU(2)$, respectively.

The most interesting property of the SM is the occurrence of neutral weak currents. A number of consequences of this prediction have been subject to experimental checks. The interaction Lagrangian for the neutral weak lepton current reads

$$\mathcal{L}_\ell = \frac{1}{2} \sqrt{g_1^2 + g_2^2} \bar{\nu}_L \gamma_\mu Z_\mu \nu_L - \frac{1}{2} \frac{g_2^2 - g_1^2}{\sqrt{g_1^2 + g_2^2}} \bar{e}_L \gamma_\mu Z_\mu e_L + \frac{g_1^2}{\sqrt{g_1^2 + g_2^2}} \bar{e}_R \gamma_\mu Z_\mu e_R, \quad (4)$$

where Z_μ denotes the neutral intermediate vector boson field. The interaction Lagrangian for

the neutral weak quark current reads

$$\begin{aligned}\mathcal{L}_q = & \frac{1}{2} \frac{g_2^2 - \frac{1}{3}g_1^2}{\sqrt{g_1^2 + g_2^2}} \bar{u}_L \gamma_\mu Z_\mu u_L - \frac{2}{3} \frac{g_1^2}{\sqrt{g_1^2 + g_2^2}} \bar{u}_R \gamma_\mu Z_\mu u_R \\ & - \frac{1}{2} \frac{g_2^2 + \frac{1}{3}g_1^2}{\sqrt{g_1^2 + g_2^2}} \bar{d}_L \gamma_\mu Z_\mu d_L + \frac{1}{3} \frac{g_1^2}{\sqrt{g_1^2 + g_2^2}} \bar{d}_R \gamma_\mu Z_\mu d_R.\end{aligned}\tag{5}$$

In analogy with the Lagrangian (2) for the electromagnetic interaction, from (4) and (5) we assume that each fundamental fermion possesses its own weak charge w , which was first reported in Ref.[7], to wit

$$\begin{aligned}w(\nu_L) &= \frac{1}{2} \sqrt{g_1^2 + g_2^2}, \\ w(e_L) &= -\frac{1}{2} \frac{g_2^2 - g_1^2}{\sqrt{g_1^2 + g_2^2}}, & w(e_R) &= \frac{g_1^2}{\sqrt{g_1^2 + g_2^2}}, \\ w(u_L) &= \frac{1}{2} \frac{g_2^2 - \frac{1}{3}g_1^2}{\sqrt{g_1^2 + g_2^2}}, & w(u_R) &= -\frac{2}{3} \frac{g_1^2}{\sqrt{g_1^2 + g_2^2}}, \\ w(d_L) &= -\frac{1}{2} \frac{g_2^2 + \frac{1}{3}g_1^2}{\sqrt{g_1^2 + g_2^2}}, & w(d_R) &= \frac{1}{3} \frac{g_1^2}{\sqrt{g_1^2 + g_2^2}},\end{aligned}\tag{6}$$

where $w(f_L)$ is the weak charge of the LH fermion f_L and $w(f_R)$ that of the RH fermion f_R , $f = \nu, e, u$, or d . Setting

$$w_1 = \frac{g_1^2}{\sqrt{g_1^2 + g_2^2}}, \quad w_2 = \frac{g_2^2}{\sqrt{g_1^2 + g_2^2}},\tag{7}$$

then

$$e = \sqrt{w_1 w_2},\tag{8}$$

and the expression (6) for the weak charge can be written as

$$\begin{aligned}w(\nu_L) &= \frac{1}{2}w_1 + \frac{1}{2}w_2, \\ w(e_L) &= \frac{1}{2}w_1 - \frac{1}{2}w_2, & w(e_R) &= \frac{1}{2}w_1 + \frac{1}{2}w_1, \\ w(u_L) &= -\frac{1}{6}w_1 + \frac{1}{2}w_2, & w(u_R) &= -\frac{1}{6}w_1 - \frac{1}{2}w_1, \\ w(d_L) &= -\frac{1}{6}w_1 - \frac{1}{2}w_2, & w(d_R) &= -\frac{1}{6}w_1 + \frac{1}{2}w_1.\end{aligned}\tag{9}$$

I.2 The weak charges of the intermediate bosons

In the SM, the Lagrangian describing the self-interaction of gauge fields is given by

$$\begin{aligned}
\mathcal{L}_{gi} = & \frac{g_2^4}{g_1^2 + g_2^2} (W_\nu^+ W_\mu^- Z_\mu Z_\nu - W_\nu^+ W_\nu^- Z_\mu Z_\mu) \\
& + \frac{g_1^2 g_2^2}{g_1^2 + g_2^2} (W_\nu^+ W_\mu^- A_\mu A_\nu - W_\nu^+ W_\nu^- A_\mu A_\mu) \\
& + \frac{1}{2} g_2^2 (W_\nu^+ W_\mu^- W_\nu^+ W_\mu^- - W_\nu^+ W_\mu^- W_\nu^- W_\mu^+) \\
& + \frac{g_1 g_2^3}{g_1^2 + g_2^2} (W_\nu^+ W_\mu^- Z_\mu A_\nu + W_\nu^+ W_\mu^- A_\mu Z_\nu) \\
& + 2 \frac{g_1 g_2^3}{g_1^2 + g_2^2} W_\nu^+ W_\nu^- Z_\mu A_\mu.
\end{aligned} \tag{10}$$

From the second term it is found that the electromagnetic interaction occurs between the electromagnetic field A_μ and the charged intermediate vector boson field W^\pm , and W^+ and W^- bosons have the electric charge e and $-e$, respectively. Comparing the first term with the second term it is assumed that W^+ and W^- bosons possess the weak charge $w(W^+)$ and $w(W^-)$, respectively, and

$$w(W^+) = \frac{g_2^2}{\sqrt{g_1^2 + g_2^2}} = w_2, \tag{11}$$

$$w(W^-) = -\frac{g_2^2}{\sqrt{g_1^2 + g_2^2}} = -w_2. \tag{12}$$

As indicated from formula (10), both the electromagnetic field A_μ and the neutral intermediate vector boson field Z_μ have no self-interaction, hence the photon has zero electric charge, and both it and Z boson have zero weak charge.

I.3 The weak charges of the hadrons

The resultant weak charge of a system is the algebraic sum of the weak charges of all particles, which are involved in the system. The hadrons are made out of quarks. Hence, the left-handed weak charge (LHWC) of a hadron is equal to the sum of the LHWC of the individual quarks, and the right-handed weak charge (RHWC) of a hadron is the sum of the RHWC of the quarks which are involved in the hadron. Considering the operation CP is conserved (so far, CP violation has only been observed in the $K^0 \bar{K}^0$ system), and the electric charges of a particle and an antiparticle are always opposite in the signs, we assume that the LHWC of a fundamental fermion f and the RHWC of an antifermion \bar{f} have equal magnitude but opposite sign, i.e.,

$$w(f_L) = -w(\bar{f}_R) \quad \text{or} \quad w(f_R) = -w(\bar{f}_L). \tag{13}$$

Thus the weak charges of some baryons and mesons can be calculated, and are listed in Table I and II, respectively. The meson has zero spin, and there exists not the LH or RH meson,

therefor the LHWC of a meson should be regarded as the weak charge in a LH system of coordinates, and the RHWC of a meson in a RH system. Since the quark combination state of π^0 meson is $(u\bar{u} - d\bar{d})/\sqrt{2}$, the weak charges of two kinds of quark-antiquark pairs, $u\bar{u}$ and $d\bar{d}$, are calculated in the Table II. The weak charge of η -meson is also calculated with the same way. From Table I and II, it is easy to see that the LHWC of a hadron is generally different from its RHWC. But, the RHWC of a neutral baryon is equal to zero, and the LHWC of a charged meson is identical with its RHWC.

II Question of parity nonconservation

As mentioned above, the LHWC and the RHWC of a fundamental fermion are different. The chiral value of the weak charge is defined as

$$\gamma_w = \frac{w(f_L) - w(f_R)}{w(\nu_L) - w(\nu_R)}. \quad (14)$$

That is to say, that $\gamma_w = +1$ for neutrino and u quark, $\gamma_w = -1$ for electron and d quark, and an antiparticle has the same γ_w as a particle. The chiral value of a hadron is equal to the sum of the chiral values of all quarks, which are involved in the hadron. The chiral value of some baryons and mesons are listed in Table I and II, respectively. It is found that the baryons have odd chiral values, i.e., $\gamma_w = \pm 1$ or ± 3 , and the mesons have even chiral values, i.e., $\gamma_w = 0$ or ± 2 . Particularly, the charged mesons have zero chiral values.

For all weak interactions involving fermions, the chirality of every particle has been analyzed in detail. In the neutron-decay, for example, since the RH neutron has zero weak charge (see table I), it does not take part in weak interaction, and the neutron must be the LH particle. The experiments have proved [8] that the electron is the LH particle, and the antineutrino is the RH in the β -decays, and then the proton must be also the LH particles in view of the conservation law of angular momentum, i.e.,

$$n_L \longrightarrow p_L + e_L + \bar{\nu}_R, \quad (15)$$

Obviously, the parity is not conserved in this process.

The pion and muon decay schemes are

$$\pi^+ \longrightarrow \mu_R^+ + \nu_{\mu L} \quad (16)$$

and

$$\mu_R^+ \longrightarrow e_R^+ + \nu_{eL} + \bar{\nu}_{\mu R}. \quad (17)$$

Since the pion has spin zero the muon and the neutrino must have antiparallel spin vectors. The muon and the neutrino have parallel momentum vectors in the laboratory coordinates, and the neutrino is LH particle, so that the μ^+ must be RH. In the subsequent muon decay, the experiment has shown the positron e^+ to be the RH particle [9]. Clearly, all of fermions are chiral and the parity is naturally violated in the two processes.

For the purely meson processes, the analysis of angular momentum can not be employed, however, the change of parity can be explained by the change of the chiral value of the weak

Table I: The weak charges of baryons

Particles	J^P	Quark Composition	LHWC	RHWC	γ_w
P		uud			
Λ_0^+		udc			
Σ^+	$\frac{1}{2}^+$	uus	$-\frac{1}{2}(w_1 - w_2)$	$-w_1$	$+1$
Σ_0^+		udc			
Ξ_0^+		usc			
n		udd			
Λ		uds			
Σ^0	$\frac{1}{2}^+$	uds	$-\frac{1}{2}(w_1 + w_2)$	0	-1
Σ_0^0		ddc			
Ξ^0		uss			
Σ^-	$\frac{1}{2}^+$	dds			
Ξ^-	$\frac{1}{2}^+$	dss	$-\frac{1}{2}(w_1 + 3w_2)$	w_1	-3
Ω^-	$\frac{3}{2}^+$	sss			
Σ_0^{++}	$\frac{1}{2}^+$	uuc	$-\frac{1}{2}(w_1 - 3w_2)$	$-2w_1$	$+3$
Δ^{++}	$\frac{3}{2}^+$	uuu	$-\frac{1}{2}(w_1 - 3w_2)$	$-2w_1$	$+3$

Table II: The weak charges of mesons

Particles	J^P	Quark composition	LHWC	RHWC	γ_w
π^+	0^-	$u\bar{d}$	$-\frac{1}{2}(w_1 - w_2)$	$-\frac{1}{2}(w_1 - w_2)$	0
K^+	0^-	$u\bar{s}$	$-\frac{1}{2}(w_1 - w_2)$	$-\frac{1}{2}(w_1 - w_2)$	0
D^+	0^-	$c\bar{d}$	$-\frac{1}{2}(w_1 - w_2)$	$-\frac{1}{2}(w_1 - w_2)$	0
B^+	0^-	$u\bar{b}$	$-\frac{1}{2}(w_1 - w_2)$	$-\frac{1}{2}(w_1 - w_2)$	0
π^-	0^-	$\bar{u}d$	$\frac{1}{2}(w_1 - w_2)$	$\frac{1}{2}(w_1 - w_2)$	0
K^-	0^-	$\bar{u}s$	$\frac{1}{2}(w_1 - w_2)$	$\frac{1}{2}(w_1 - w_2)$	0
D^-	0^-	$\bar{c}d$	$\frac{1}{2}(w_1 - w_2)$	$\frac{1}{2}(w_1 - w_2)$	0
B^-	0^-	$\bar{u}b$	$\frac{1}{2}(w_1 - w_2)$	$\frac{1}{2}(w_1 - w_2)$	0
π^0	0^-	$u\bar{u}$	$\frac{1}{2}(w_1 + w_2)$	$-\frac{1}{2}(w_1 + w_2)$	+2
		$d\bar{d}$	$-\frac{1}{2}(w_1 + w_2)$	$\frac{1}{2}(w_1 + w_2)$	-2
η	0^-	$u\bar{u}$	$\frac{1}{2}(w_1 + w_2)$	$-\frac{1}{2}(w_1 + w_2)$	+2
		$d\bar{d}$	$-\frac{1}{2}(w_1 + w_2)$	$\frac{1}{2}(w_1 + w_2)$	-2
		$s\bar{s}$	$-\frac{1}{2}(w_1 + w_2)$	$\frac{1}{2}(w_1 + w_2)$	-2
K^0	0^-	$d\bar{s}$	$-\frac{1}{2}(w_1 + w_2)$	$\frac{1}{2}(w_1 + w_2)$	-2
\bar{K}^0	0^-	$\bar{d}s$	$-\frac{1}{2}(w_1 + w_2)$	$\frac{1}{2}(w_1 + w_2)$	-2
D^0	0^-	$c\bar{u}$	$\frac{1}{2}(w_1 + w_2)$	$-\frac{1}{2}(w_1 + w_2)$	+2
\bar{D}^0	0^-	$\bar{c}u$	$\frac{1}{2}(w_1 + w_2)$	$-\frac{1}{2}(w_1 + w_2)$	+2
B^0	0^-	$d\bar{b}$	$-\frac{1}{2}(w_1 + w_2)$	$\frac{1}{2}(w_1 + w_2)$	-2
\bar{B}^0	0^-	$\bar{d}b$	$-\frac{1}{2}(w_1 + w_2)$	$\frac{1}{2}(w_1 + w_2)$	-2

charge. If the sum total of chiral value of a system is constant before and after decay, i.e., $\Delta\gamma_w = 0$, then the parity must be conserved; conversely, if $\Delta\gamma_w \neq 0$, then the parity must be not conserved. For example, the value of γ_w involved in the K -decay are as follows:

$$K^+ \rightarrow \pi^+ + \pi^+ + \pi^-, \quad K^0 \rightarrow \pi^+ + \pi^- + \pi^0. \quad (18)$$

γ_w	0	0	0	0	-2	0	0	-2
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The total chiral value of every system is constant on the two sides of the equation, i.e., $\Delta\gamma_w = 0$, therefor the parity is conserved. In the processes

$$K^+ \longrightarrow \pi^+ + \pi^0, \quad K^0 \longrightarrow \pi^+ + \pi^-, \quad (19)$$

γ_w	0	0	-2	-2	0	0
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$\Delta\gamma_w \neq 0$, so that the parity is not conserved.

In brief, the weak charges of particles cause them to exert weak interactions on one another, like electric charge. Therefor the left-right asymmetry of the weak charge certainly leads to that the Hamiltonian \mathbf{H} describing weak interactions will not be invariant under inversion of space coordinates, and parity conservation law must be violated. Because the electric charges and the colour charges of fundamental fermions do not exhibit any chirality, the parity is conserved in the strong and electromagnetic interactions. T. D. Lee and C. N. Yang said: "Should it further turn out that the two-component theory of the neutrino described above is correct, one would have a natural understanding of the violation of parity conservation in processes involving the neutrino. An understanding of the $\theta - \tau$ puzzle presents now a problem on a new level because no neutrinos are involved in the decay of $K_{\pi 2}$ and $K_{\pi 3}$. Perhaps this means that a more fundamental theoretical question should be investigated: the origin of all weak interactions." [10] Now, by introducing the concept of weak charge, this problem can be reasonably and intuitively explained.

III The conservation law of the weak charge

For all weak interactions, the change of the weak charge of every system has been calculated in detail, and the conservation law of the chiral weak charge is discovered. To understand this let us consider, for example, the β -decay. In the neutron-decay (15), according to the formula (9) and Table I, we get

$$w(n_L) = w(p_L) + w(e_L) + w(\bar{\nu}_R) \quad (20)$$

That is to say, the chiral weak charge of the system is constant before and after decay.

The conservation law of the chiral weak charge can be confirmed in terms of the Feynman diagrams. The interaction Lagrangian for the charged weak lepton currents is given by

$$\mathcal{L}_{\ell W} = \frac{1}{\sqrt{2}} g_2 \bar{e}_L \gamma_\mu W_\mu^+ \nu_L + \frac{1}{\sqrt{2}} g_2 \bar{\nu}_L \gamma_\mu W_\mu^- e_L. \quad (21)$$

The Feynman diagrams corresponding to the interactions are shown in Fig. 1.

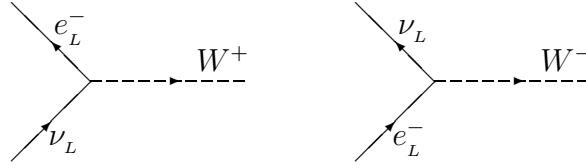


FIG. 1. Diagram for the weak interaction of an electron with a neutrino.

The interaction Lagrangian for the charged weak quark currents is given by

$$\mathcal{L}_{qW} = \frac{1}{\sqrt{2}} g_2 \bar{d}_L \gamma_\mu W_\mu^+ u_L + \frac{1}{\sqrt{2}} g_2 \bar{u}_L \gamma_\mu W_\mu^- d_L. \quad (22)$$

The Feynman diagrams corresponding to the interactions are shown in Fig. 2.

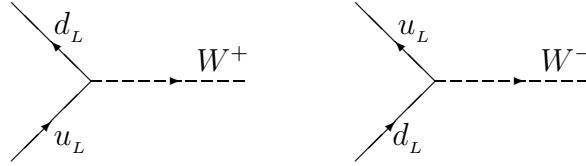


FIG. 2. Diagram for the weak interaction of a u quark with a d quark.

It is obvious from Fig.1 and Fig.2 that the chiral weak charge is always conserved at every vertex of Feynman diagrams, like the electric charge, angular momentum, etc.

For the purely meson weak interactions, if the intrinsic parity of a system is conserved the LHWC and the RHWC of the system will be conserved respectively, such as processes (18). Otherwise, if the intrinsic parity of a system is not conserved, the LHWC and the RHWC of the system will be not conserved, respectively, such as the processes (19).

It is surprisingly found that, however, the total net weak charge of any system, the sum of the LHWC and the RHWC, is always conserved in all weak interactions, although the LHWC and the RHWC of the system may be not conserved, respectively. For strong and electromagnetic interaction processes the conservation law of the total weak charge has also been inspected one by one, and found this to be so.

Lastly, we can draw the diagram of the π^+ decay, as shown in Fig.3, which involving an intermediate $p\bar{n}$ state. At strong interaction vertex A, the total weak charge is conserved. At weak interaction vertex B and C the chiral weak charge is also conserved, respectively.

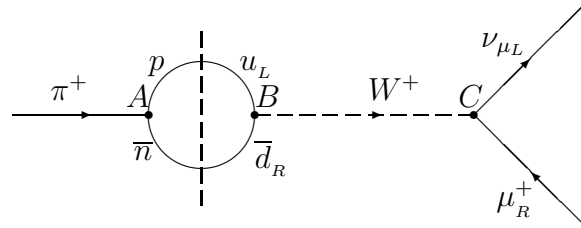


Fig. 3. Diagram for the decay of π^+ meson.

IV The extension of the standard model

As seen from formula (9), there exist the symmetries of the weak charge among the fundamental fermions, and between the LH and the RH fermions. In accordance with this symmetry, it is natural to assume that the RH neutrinos might be present in the universe and possess weak charge

$$w(\nu_R) = \frac{1}{2}w_1 - \frac{1}{2}w_1 = 0. \quad (23)$$

This implies that the neutrinos are massive. In the SM, the neutrino has only the LH states, the antineutrino has only the RH states, and their masses must be zero. Now, one can extend the SM gauge group to include the RH neutrino fields ν_R as SU(2)-singlets. Obviously, the weak isospin and the supercharge of the RH neutrino are both zero, so that the RH neutrino fields ν_R are not present in interaction Lagrangian for the neutral and the charged weak lepton currents. We also extend the SM to include the Higgs scalar fields ϕ' as SU(2)-doublet, which is charge conjugate of the standard Higgs doublet ϕ , i.e., $\phi' = -i\tau_2\phi^*$. Dirac-type mass terms are generated by the Yukawa-type interaction of the lepton doublets or singlets with Higgs scalar fields. The mass terms thus generated can contain, in addition to the ordinary mass term of the charged lepton, the mass term of neutrino, which is similar to that of u quark. In this scenario neutrinos are treated on an equal footing with the other fermions of the theory, and there exists a complete analogy between the weak interaction of leptons and quarks. Both the RH neutrino and the LH antineutrino have zero weak charges, so that they do not take part in weak interaction and are termed the dark particles. B. Pontecorve [11] called them the ‘sterile’ neutrinos, which with definite mass are Majorana particles, not Dirac particles. With the dark-massive Dirac neutrinos it is possible to explain simultaneously the solar neutrino deficit [12], the atmospheric neutrino anomaly [13], the LSND data [14], and the hot dark matter problem of the universe [15].

In conclusion the standard model has been extended to include the right-handed neutrinos. Similar theory has been discussed before [16], however, there exist some outstanding characteristics in this new scenario:

(1) Not only RH neutrinos, but also RH neutral baryons have zero weak charges, and they do not take part in weak interactions. Therefore the lifetime of right-handed polarization neutral baryons should be greater than that of left-handed polarization neutral baryons. This problem will be discussed elsewhere. An experiment with a lifetime difference between RH and LH polarization baryons, for example neutrons, needs to be performed. The report on the experiment has not yet been discovered from the literature.

(2) The concept of electric charge is familiar to most people, while the weak charge is something new. In Fermi weak interaction theory, coupling constant G is called weak charge in analogy with the current-current interaction in QED. In the SM, coupling constant g_2 is called weak charge in analogy with the $V - A$ theory. Either of G and g_2 is a universal constant for all particles. However, the weak charges mentioned in this paper are introduced by analogy between the Lagrangian for neutral weak currents and the electromagnetic currents, and different particles have different weak charges. In addition, it is more significant that the weak charges possess the symmetry and the chirality.

(3) Comparing formula (8) with (9) one can see that the conservation law of the weak charge is essentially different than that of electric charge. In the SM, the electric charge is the only conserved quantum number after spontaneously broken symmetry. Therefore, the weak charge added a new conserved quantum number to the extension model proposed in this paper. The conservation of the weak charge should correspond to a certain internal symmetry of the fundamental fermion, which is at present unknown, implies some physics beyond the SM and needs to be investigated further.

(4) As seen from (9), the weak charge of a fundamental fermion can be attributed to the linear combination of two parts, an inherent weak charge and an intrinsic chiral weak charge. The inherent weak charge of a lepton is $\frac{1}{2}w_1$ and one of a quark $-\frac{1}{2}w_1$. Because each quark has three kinds of colour, a coloured quark has the inherent weak charge of $-\frac{1}{6}w_1$. The intrinsic chiral weak charge of the LH fermion is $\pm\frac{1}{2}w_2$, and one of the RH fermion $\pm\frac{1}{2}w_1$. Thus, the weak charge of a fermion consists of two parts, and the quantum number of each part can have values of $+\frac{1}{2}$ or $-\frac{1}{2}$, like spin or isospin. Since the charged weak interaction is seen to be dominated by a coupling to left-handed fermions, the weak charge w_2 interacts on the charged intermediate boson W^\pm and the weak charge w_1 , on the neutral intermediate boson Z . This property of the weak charge might hint some information about the internal structure or certain symmetry of the fundamental fermions.

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